SOIL FUMIGATION AND SURFACE SEAL METHODS ON 1,3-DICHLOROPROPENE AND CHLOROPICRIN EMISSIONS IN AN ORCHARD REPLANT FIELD TRIAL

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An orchard field trial in Fall 2005: Soil fumigation is essential for successful replanting in many orchards and vineyards. Most soil fumigants are volatile organic compounds (VOCs) that form harmful ground level ozone when released to the atmosphere and reacting with NO_x under the sunlight. Reducing emissions is necessary to minimize fumigant contribution to air pollution. In November 2005, we carried out a field trial on a Hanford sandy loam soil in a peach replant orchard. The objective of this field trial was to determine emissions from shank- and drip-applications of fumigants as well as various surface seal methods. Use of plastic tarp is too expensive for most orchard growers as well as many vegetable growers in the Central Valley of California. Water application to soil surface (water seal) after shank-injection or with sub-surface drip application of fumigants were studied and compared with plastic tarp treatments in this trial.

Telone products (Telone C35 for shank injection and InLine for drip irrigation) were applied to the soil in the field trial with the treatments listed in Table 1. Sampling and measurements for the emissions and distribution of 1,3-dichloropropene (1,3-D) and chloropicrin (CP) in the soil-gas phase were made for two weeks following fumigation. Citrus nematode bags were buried at 30, 60 and 90 cm depth prior to fumigation and retrieved for live nematode counting after fumigation. During the field trial, the maximum and minimum air temperature ranged from 13-27^oC and 3-12^oC, respectively. Actual application rates for shank-injection were 20% higher than drip applications. Total emission losses were calculated as percent of applied to facilitate comparison of fumigant emissions between the treatments.

Results: The control treatment resulted in the earliest and highest emissions (up to 76 $\mu g\ m^2\ s^{-1}$), followed by the HDPE tarp over shank injection (up to 70 $\mu g\ m^2\ s^{-1}$) (Figure 1). The emission peaks occurred at 15 h for the control and 48 h for the HDPE tarp after fumigation. Reasons for this difference are not apparent but the results indicate that HDPE tarp is not effective in reducing 1,3-D emissions in a relatively cool fall season although the emission peak may be delayed. Pre-irrigation for shank injection resulted in much lower peak emission rate than HDPE tarp (26 $\mu g\ m^2\ s^{-1}$). This illustrates that irrigation prior to fumigation can also effectively reduce fumigant emissions. The VIF tarp resulted in large variations in emission rates (<1-26 $\mu g\ m^2\ s^{-1}$) in this field trial. Fumigation through drip application generally resulted in lower emission rates than shank injections. Emission rates of CP showed similar trend as 1,3-D except with much lower values than 1,3-D (data not shown). In addition, HDPE tarp over shank injection resulted in much lower CP emission rates than 1,3-D in comparison to the control. This indicates that HDPE is more effective in reducing CP emissions in comparison with 1,3-D.

Cumulative emission losses as percent of applied over a 2-wk monitoring period after fumigation are shown in Table 2. The control and HDPE tarp resulted in the highest 1,3-D emission loss in the first week. The emission loss from HDPE tarp exceeded the control thereafter (data not shown). Total losses of 1,3-D were 36% for the control (with large variation) and 43% for the HDPE tarp, respectively. Total emission losses from the pre-irrigation and VIF tarp over shank applications were about half of the control and HDPE tarp. Emission loss for VIF tarp over shank application was lower than the pre-irrigation initially but increased steadily up to the end of the monitoring. The VIF tarp could retain the fumigants under the tarp but degradation of the tarp impermeability may have caused emission increases over time. Drip applications with HDPE tarp and water applications before and after drip application resulted in the lowest and similar emission losses (12% and 13%, respectively for 1,3-D; and 2% and 3%, respectively for CP). This indicates that water applications before and after fumigation through drip irrigation can also reduce emissions as effectively as HDPE tarp.

Total emission loss of CP generally followed a similar pattern as 1,3-D except that HDPE tarp reduced CP emission more effectively than 1,3-D. Total percent losses of CP were generally lower than 1,3-D for the same treatment. This had been consistently observed and it has been attributed mainly to the differences between the two compounds. Chloropicrin is less volatile and also has much a shorter aerobic soil metabolism half-life than 1,3-D.

All treatments provided 100% kill of the nematodes from bags buried in the field while 4,000 live citrus nematodes per bag were retrieved from non-treated fumigation areas. This indicates that with the application rates and methods used in the field trial, the fumigation provided efficient control of citrus nematodes in this soil.

Conclusion: Results from this orchard field trial confirmed the ineffectiveness of HDPE tarp by itself in reducing 1,3-D emissions. Irrigation to produce a moist soil profile in the top 25-cm prior to soil fumigation effectively reduced 1,3-D and CP emission peaks as well as total emissions. The soil water content was about 10% throughout the soil profile, which is about 60% of field capacity. As soil water content increases, fumigant diffusion within the soil profile and emissions would decrease. Further studies are needed to clearly define the optimum soil moisture condition for different types of soil to reduce emissions while maintaining adequate fumigation efficacy.

Table 1. Fumigation and surface treatments for emission study in fall 2005 field trial on a Hanford sandy loam soil near Parlier, CA

Fumigant[a]	Application[b] Method	Application rate[c] (kg/ha)	Soil seal methods[d]
Telone C-35	Shank	745	Control (dry soil, disk, harrow)
Telone C-35	Shank	745	HDPE (dry soil, disk, harrow)
Telone C-35	Shank	745	VIF (dry soil, disk, harrow)
Telone C-35	Shank	745	Pre-irrigate (~40 mm water sprinkler applied, disk, harrow)
InLine	Drip	629	HDPE
InLine	Drip	629	Water applications (8-mm water pre- and post-fumigation)

[a] Telone C35: 61% 1,3-D, 35% CP, 4% inert ingredients; InLine: 61% 1,3-D, 33% CP, 6% inert ingredients.

[b] Fumigants were applied in strips (strip width was 3.7 m for shank injection and 3.2 m for drip application). All shank treatments were disked and harrowed following fumigation. The Telone products were applied 46 cm deep with 7 shanks spaced 46 cm apart. For drip-applied treatments, drip tapes (30 cm emitter spacing) were installed 20 cm below the soil surface on 46 cm spacing. InLine was applied with 15 cm of irrigation water over 25 h.

[c] This was the actual application rate, which was about 20% higher than the target rate for shank injection.

[d] For pre-irrigation - shank treatment, strips were pre-irrigated with micro-spray sprinklers 4 days before fumigation to achieve near field capacity soil water content to 25 cm depth. For the water caps in drip-fumigation treatment, 12 mm of sprinkler irrigation water was sprinkled just before and following application. Tarps were applied after shank-injection and before drip-application. Duplicate measurements were made for each treatment.

Table 2. Total emission loss of 1,3-dichloropropene (1,3-D) and chloropicrin (CP) measured over 2 wks after fumigation in fall 2005 field trial on a Hanford sandy loam soil near Parlier, CA.

Treatment	1,3-D	CP
	--------------- (% of applied)	-------
Control (shank - Telone C35)	36.1 (7.1)	30.4 (2.9)
Shank - Telone C35 - HDPE	43.0 (0.4)	16.9 (0.0)
Shank - Telone C35 - VIF	18.7 (0.7)	7.9 (0.1)
Shank - Telone C35 – pre-irrigation	19.2 (0.5)	8.8 (0.2)
Drip - InLine - HDPE	12.3 (2.3)	2.0 (0.4)
Drip – InLine - water applications pre- and post-fumigation	12.7 (4.7)	2.9 (1.5)

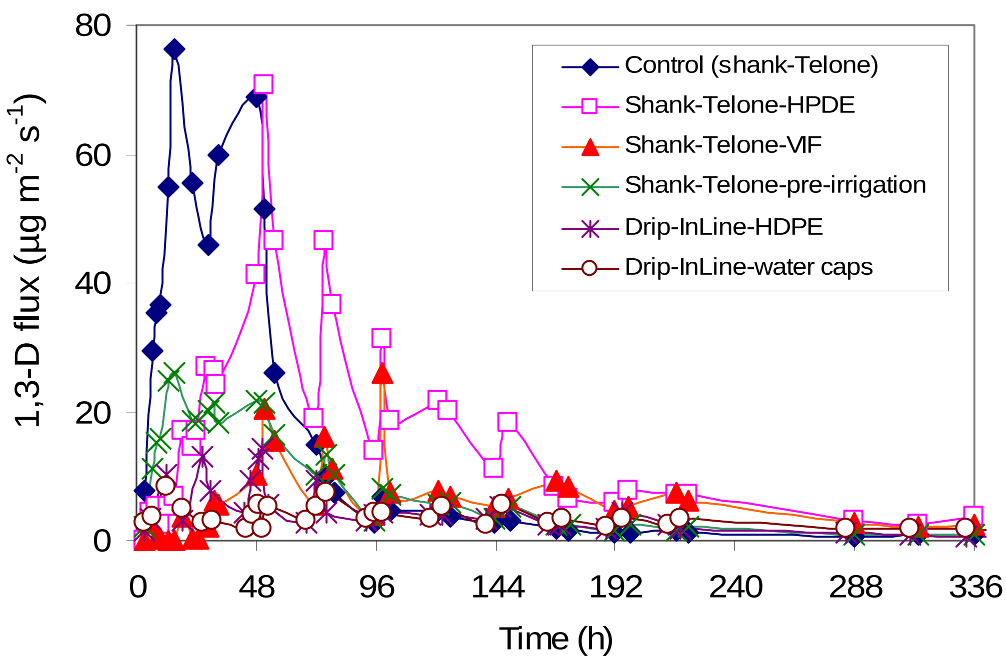

Figure 1. Effects of application methods and surface seal treatments on emission flux of 1,3-dichloropropene (1,3-D) from Telone C35 (shank-injection) and InLine (drip-irrigation) applications in an orchard field trial conducted in November 2005. Plotted data are averages of duplicate measurements.